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The Conversion of Freeway Shoulders to Traffic Lanes for Local Congestion Relief

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EXECUTIVE SUMMARY

CONCLUSIONS:

1/ Structurally strengthened, a freeway shoulder can be converted into a driving lane.

2/ The use of freeway shoulders around bottleneck sections must be considered as one of several alternatives.

3/ Operational and safety experiences by other jurisdictions are generally favourable.

4/ When considering all readily quantifiable benefits and disbenefits, the use of freeway shoulders shows a very high benefit to cost ratio.

RECOMMENDATION:

That the Ministry consider the use of freeway shoulders as an option in the elimination of localized congestion, but only under the following circumstances and conditions:

- considered on a site-specific basis
- the capacity improvement will not result in a displacement of the problem upstream or downstream
- other alternatives which retain shoulders should be first studied and evaluated
- traffic lanes must be equal to or greater than 3.35 m (11 ft)
- a minimum of one full shoulder be retained per roadway
- complete site-specific evaluation of the impact on emergency vehicle operation, maintenance and safety

1/ INTRODUCTION

The approach applied in this study was divided into two parts, consisting of five major tasks. In Part I, all issues and concerns related to the use of freeway shoulders were addressed, and general conclusions derived. In Part II, a case study, the conclusions derived in Part I were applied to one specific section of the Highway 401. The case-study of Part II translates the conclusions of Part I into an evaluation process and serves to illustrate the site-specific nature of this alternative.

The use of freeway shoulders is not the only way to eliminate local bottlenecks on freeways. For any given site, the use of the freeway shoulder should be considered as one possible alternative which must compete against various other solutions to the same problem.

1.1/ Study Approach

Part I Derivation of Guidelines for Shoulder Use

Task 1

- review of shoulder use by other jurisdictions
- literature search
- review of geometric design criteria
- design and implementation considerations

Task 2

- examination of concerns and issues related to use of freeway shoulders
- structural integrity
- safety
- lane balance/lane continuity
- maintenance and snow/sand removal/debris removal
- guiderail repairs
- sign structure maintenance and relamping
- incident management
- driver acceptance
- operational emergency vehicles
- cost

Task 3
- Derivation of conclusions

Part II Case Study

Task 4
- site selection
- preliminary design

Task 5
- detail evaluation of freeway shoulder use alternative using the conclusion of Part I

A graphic representation of the study organization is shown in Figure 1.

1.2/ Study Background

March 12/81 -- Request from T.G. Smith to prepare a policy paper on this item for discussion at the Provincial Highway Planning Committee.

May 28/81 -- Policy paper submitted to T.G. Smith.

July 24/81 -- Mr. T.G. Smith requested a presentation on this topic to the Provincial Highway Planning Committee.

Aug. 17/81 -- Presentation made to the Provincial Highway Planning Committee. R. Shannon instructed to present material to the Highway Engineering Research and Development Steering Committeee to determine if more detailed study was required.

Oct. 29/81 -- Presentation made to the Highway Engineering Research and Development Steering Committee and it was decided "a detailed study should be initiated as soon as possible".

Jan. 25/82 -- Initial meeting of Task Force on the use of freeway shoulders for increased capacity.

April 20/82 -- Presentation of interim results of the study to the Provincial Highway Planning Committee.

Aug. 12/82 -- Draft report of results distributed to the Task Force.

Sept. 21/82 -- Final presentation scheduled to the Provincial Highway Planning Committee.

1.3/ Study Participants

The following agencies and MTC departments participated in the study:

1/ OPP -- Inspector H. Wilson

2/ MTC -- Central Region Traffic Eng. -- R. Shannon
Central Region Planning & Design -- I. Ardizone
Traffic Eng. Office -- H. Anders
Highway Planning & Design -- H. McIntyre
Central Region Maintenance -- D. Aspinwall
Control Systems & Communications -- G. Abrahamsohn

The study was headed by a steering committee lead by R. Shannon. The principal investigator was G. Abrahamsohn. Other part-time participants were:

- W. Friedman -- Planning & Design
- F. Norman -- Planning & Design
- D. Collins -- Maintenance

2/ DESIGN AND IMPLEMENTATION CONSIDERATIONS FOR THE USE OF FREEWAY SHOULDERS TO ELIMINATE LOCAL BOTTLENECKS

2.1/ Lane Widths

"There is virtually no useful information in the recent literature which permits any consideration of revision of the lane width and lateral clearance adjustment factors in the Highway Capacity Manual (HCM). Those in the HCM were based on a sparse data base consisting of data from the late 1940's. Indeed, the lane width factors of the 1965 HCM were based on the same data as those of the 1950 HCM".
(Freeway Capacity Procedures, D.O.T. Feb. 1978, Interim Report).

The accepted desirable standard width of a freeway lane is 3.65 m (12 ft). This standard is based on a report by A. Taragin "Effect of Roadway Width on Traffic Operations -- Two-lane Concrete Roads," Proceedings of HRB 24th Annual Meeting 1944. The report concluded that for mixed passenger and commercial vehicle traffic on two-lane roadways with meeting, as well as passing conditions, lane widths of 3.65 m are required. Some limited access facilities have operated successfully with lane widths less than 3.1 m (10 ft). Many agencies prefer not to reduce the lane width below 3.35 m (11 ft). With low truck traffic volumes lane widths of 3.2 m (10.5 ft) have been used.

2.1.1/ Uniformity of Lane Widths

On freeways, common practice is to use equal lane widths, each 3.65 m wide. On divided highways, combinations of one lane 3.95 m wide and the other 3.65 m wide for each one way roadway are sometimes used. Where conditions along the inner and outer edges of the pavement are alike, there is little to choose between the use of equal and unequal lanes. Where unequal width lanes are used, it makes little difference on which side the wider lane is located. When the wider lane is located on the outside (right) it provides more space for large vehicles which usually occupy that lane. It also allows drivers to keep their vehicles at a greater distance from the right edge of pavement. When located inside (next to the median), the wider lane provides more space for passing vehicles in the outer lane. The basic design determination is the total

pavement width, and the placement of the pavement stripes actually governs the lane width.

2.1.2/ Lane Balance

"For smooth and efficient operation through an interchange, there should be a balance between the number of traffic lanes in the roadway and the ramps." (RTAC)

2.1.3/ Lane Continuity

In freeway design it is desirable that not only the number of basic lanes be maintained, but also that the basic lanes remain continuous. In the case of a roadway with a collector/express configuration, transfer roads result in the loss of left lane continuity. While it is necessary in some designs to accept some loss of lane continuity, every effort should be made to retain it.

2.1.4/ Conclusion

Whereas the accepted desirable lane width standard for freeways is 3.65 m (12 ft) several agencies have operated successfully with lane widths below this standard. In Ontario, the most appropriate example to consider is that of Highway 401 near Rittson Road in Oshawa. For a 2.1 km section of the freeway, the lane widths are 3.4 m (11 ft). This section of the freeway appears to operate with no adverse effects. Based on experience in Ontario and elsewhere the tentative conclusion is that, in some cases, for limited freeway sections and with careful design, lane widths of 3.4 m (11 ft) can be tolerated.

2.2/ Shoulders

A shoulder is the portion of the roadway contiguous with the travelled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses. The following summarizes the main functions and advantages of well designed and properly maintained shoulders:

1/ It provides space for stopping free of the traffic lane.

2/ It provides space to escape potential accidents, or in some instances, to reduce their severity.

3/ It improves the capacity of the highway.

4/ It provides space for snow storage.

5/ It provides structural support for the pavement.

6/ Provides refuge during incidents.

7/ Provides space for maintenance operations.

Note also that in the case of a freeway with a collector/express configuration, the function and utility of each shoulder is different from snow removal, maintenance and incident processing points of view. This must be kept in mind when considering implementation of freeway shoulder use projects.

2.2.1/ Space for Stopping Free of the Traffic Lane

A shoulder should be wide enough for a vehicle to be driven completely off the pavement. However, there are considerable, (though fewer) advantages in narrower shoulders.

Desirably, a vehicle stopped on the shoulder should clear the pavement edge by at least 0.3 m (1 ft). If working space is needed, at least 0.6 m clearance is required. For passenger cars of 1.8 m bodywidth and for trucks of 2.5 m bodywidth, the required shoulder width becomes 1.8 + 0.6 = 2.4 m and 2.5 + 0.6 = 3.1 m, respectively. This has led to the adoption of 3 m (10 ft) as the compromise shoulder width that should be provided along major facilities.

The AASHO Blue Book 1972 recommends continuous shoulders regardless of width. "However, significant savings made possible by the reduction of shoulder widths for short distances cannot be ignored, for narrow and

intermittent shoulders have worth and are much superior to no shoulders."

On freeways with two or more lanes, outside shoulders and median shoulders vary in width. A comprehensive NCHRP study into the design and use of highway shoulders revealed that most agencies used 3 m for the outside and 1 2 m for the median shoulder. MTC uses 3 m for right shoulders and 2.1 m for left shoulders as a design standard on freeways.

2.2.2/ Safety Aspect of Shoulders

Considerable controversy rages over the influence of shoulders on accident rates and accident severity. Some studies show evidence supporting the benefits of shoulders, others take the opposite view.

With a continuous shoulder almost all drivers making emergency stops will leave the pavement. When a vehicle ahead has stopped on the pavement a hazardous condition results because it is difficult for motorists to discern that the vehicle is not moving unless people are standing near it. To assess the utility of shoulders for safety, a rough comparison of accident rates on Highway 401 Toronto Bypass and QEW (from Ford Drive to Dixie Road) was carried out. On Highway 401 only the collector roadway was considered to reflect the similar entrance and exit conditions which exist on the QEW.

Highway 401 has shoulders on both sides, with the outside shoulder generally 3 m and the median shoulder varying from 2 to 3 m. The QEW only has an outside shoulder.

A few words of caution. the QEW operates at a higher level of congestion and generally taxes the motorists more than Highway 401.

For the purposes of comparison, annual average daily trafic volumes (AADT) and accident rates were averaged over the past eight years. The results shown in Table 1 do not show significant differences in the accident rates. To gain more insight, the fixed object collisions left side only, were examined for both facilties. Tables 2 and 3 show the results which reveal that the QEW experiences a significantly higher

proportion of fixed object collision on the left side than does Highway 401. This suggests that from an accident types point of view the QEW (no left shoulder) is worse in some respects and better in others, than the Highway 401 Toronto Bypass.

2.2.3/ Combined Effect of Lane Width and Restricted Lateral Clearance on Capacity

The report by Taragin "Effect of Roadway Width on Traffic Operations -- Two-lane Concrete Roads", indicated that shoulder widths in excess of 1.2 m (4 ft) had little impact on traffic operations. The Highway Capacity Manual (April 1972) gives a more detailed breakdown of the combined effect of lane width and restricted lateral clearance on capacity (see Table 4).

There are three important observations apparent from Table 4:

1/ A shoulder width (distance from traffic lane edge to obstruction) in excess of 1.2 m (4 ft) has hardly any effect on capacity.

2/ From a traffic operations point of view, shoulders on both sides are best, but a shoulder one side of the freeway provides a small capacity gain over the no shoulder configuration.

3/ The HCM suggests that lanes narrower than 3.65 m have a detrimental effect on the capacity, even if trucks are excluded from traffic. This contradicts Taragin's findings which concluded that 2.75 m (9 ft) lanes are totally adequate for passenger car traffic.

2.2.4/ Conclusion

Eliminating the shoulder from one side of the roadway results in a loss in capacity. Shoulder widths in excess of 1.2 m (4 ft) do not result in any increase in capacity.

Lane widths lower than 3.65 m (12 ft) result in lower capacity. With an adequate shoulder on one side and no shoulder on the other, the HCM suggests a 9% capacity reduction.

In summary, the lowering of the lane width and the elimination of a shoulder results in a loss of lane capacity. Therefore, the addition of another lane will not result in the gain of a full lane's worth of capacity (see Table 5).

3/ MAINTENANCE CONSIDERATIONS

There are two types of maintenance activities-- scheduled maintenance and unscheduled maintenance. As the names imply, "scheduled maintenance" refers to activities which can be scheduled, and "unscheduled maintenance" refers to activities which arise from some random and unforseen happenings.

3.1/ Scheduled Maintenance

Sand Removal

Sand removal is a maintenace operation which is started in the spring and continues through the summer. To carry out the sand removal operation without adequate shoulder requires that one lane be closed.

This means that the operation is accompanied by delays and inconvenience to the motorists. Without an adequate shoulder, the sand removal activity must be confined to the off-peak period.

Snow Storage and Snow Ploughing

One important consideration in the attempt to use the freeway shoulder to increase capacity is the impact on the snow ploughing and snow storage activities. Particularly in areas with heavy snow fall, these can become very important issues. The elimination of a freeway shoulder will definitely impact snow removal and snow ploughing activites. Depending on which shoulder is eliminated, the impact on snow storage can be very serious, or it can be tolerable. With a core/collector configuration, the right shoulder in the collector is used heavily for snow storage. Probably the left shoulder in the core roadway is the least needed for snow storage.

MTC's policy is to clear all lanes in one direction. Snowploughs are operated in tandem, and full, 100% sweep is accomplished. Adding an extra lane over a section of the freeway may necessitate the addition of an extra snowplough and operating personnel (six per plough).

In case of a heavy snow fall, both the left and the right shoulders are used to store snow. Eliminating the left shoulder would require that all

the snow be stored on the right shoulder or it would require that a lane be lost.

Catch Basin Clearance

With adequate shoulder areas, the catch basin can be maintained without lane closures. Work can be carried out at night, and is usually based on a 10 h work period. Without adequate shoulder areas, the work on the catch basin would require the closure of one, or possibly even two lanes (one in the opposite direction). Since the catch basins are approximately 100 to 150 m apart, a considerable amount of time would be required for setting up and clearing the lane closures.

Zone-Painting and Sealing

Zone-painting and sealing are scheduled maintenance operations which rely heavily on the existence of adequate shoulder area.

3.2/ Non-Scheduled Maintenance

Lumped under this category are all those maintenance actions which are the result of unforeseeable occurrences such as accidents, appearance of debris on the roadway, etc. The required maintenance operation cannot be scheduled to fall outside of the peak period and consequently the impact of these operations on traffic is potentially very high.

The presence of adequate shoulder area facilitates the non-scheduled maintenance activities and minimizes traffic disruptions. There is no adequate data base to quantify the impact and to compare the operation with or without adequate shoulder area.

3.3/ Conclusions

Both scheduled and non-scheduled maintenance operations are affected by the presence/absence of adequate shoulder area. In particular, however, non-scheduled maintenance activities with their potentially heavily disruptive impact on traffic are adversely affected by the elimination of adequate shoulder area.

4/ STRUCTURAL CONSIDERATIONS

In general, the shoulder design is not adequate to carry traffic -- particularly truck traffic -- on a continuous basis The slope of the shoulders is usually quite a bit higher than that of the pavement.

4.1/ Pavement Surfaces

Only few projects have resorted to a total resurfacing with the modification of the cross-section. Usually the texture, colour and contrast of the mainline and shoulder pavements are different. If the lane delineation is good, the pavement contrast does not adversely affect the use of the lane.

After an extended period of operation, the surface of the shoulder may deteriorate, and the joint between the mainline and shoulder pavements may enlarge. This of course, is only true if the shoulder has not been redesigned to carry the extra load.

4.2/ Conclusion

Regardless of the design details, the existing shoulder design is not adequate to carry traffic on a continuous basis.

5/ INCIDENTS

Incidents result in significant traffic disruptions, and approaches to the reduction of recurrent congestion must be assessed against their impact on the delay during non-recurrent (incident) conditions.

5.1/ Incident Frequency

In Volume 2, "Problem Identification," of the Highway 401 TM Study, the frequency of incidents on the Hwy. 401 was established as follows:

Non-accident caused incidents = $9.7/10^6$ veh-km (probably high) (Average)
Accident caused incidents = $1.3/10^6$ veh-km (Average)

For a three-lane roadway (collector or express), based on 5000 veh/h peak volumes and a peak period of 5 h (morning and evening), on the average there will be 0.25 incidents/day/km. In other words, on the average, in every 1 km section there will be one incident every four days.

5.2/ Incident Delay

If the demand during the incident exceeds the residual capacity of the roadway, queues will be formed. The queue dissipation following incident removal depends on the ratio of the demand volume to the capacity of the roadway. If the demand volume is lower than the capacity of the roadway, the queue will be dissolved.

If the capacity of the roadway is equal to or less than the demand volume, the queue will not be dissolved (it may even grow) until the demand volume falls below the capacity.

If the V/C ratio of a congested section before improvement is 0.9 or higher, incidents will cause heavy delays. The addition of a lane by taking away a shoulder reduces the recurrent congestion over that section and the V/C ratio will be of the order of 0.7. Even if it is assumed that some of the vehicles have to be pushed over four lanes to find a resting place on the shoulder, the incident caused delays are far less for the lower V/C case. For the constant demand case, the addition of a

lane practically eliminates incident caused delays for the affected section.

5.3/ Incident Severity

Without the presence of a shoulder on at least one side, some vehicles will undoubtedly be stranded in the driving lanes, posing a hazard to themselves and others. The severity of accidents on the QEW does not appear to be much different from that seen on the Highway 401 Toronto Bypass. Nevertheless, the addition of a 4th lane and the elimination of a shoulder will have a detrimental impact. The quantification of this impact is very difficult. With respect to incidents, there is another issue to consider -- with shoulder on both sides on the roadway, a "good" number of disabled vehicles can coast and find refuge on the shoulder. When one shoulder is eliminated, there will be disabled vehicles which will not be able to safely coast across a number of lanes to seek a safe spot on the shoulder. These vehicles will have to stop on the roadway and present a hazard as well as a delay causing situation. In the assessment of shoulder use this issue must also be considered. The case study in Part II will show how this can be accomplished.

6/ SUMMARY OF CONCLUSIONS

1/ Review of experiences by other jurisdictions and available literature indicates that for limited sections, lane widths of 3.5 m (11 ft) are acceptable and do not pose safety problems. Indeed, a 2.1 km section of the Highway 401 near Rittson Road in Oshawa operates with 3.35 m lane widths (50 000 AADT) and without any apparent safety or operational problems.

2/ Review of experiences by other jurisdictions and similar freeway operations throughout Ontario showed that under certain cirumstances the elimination of a freeway shoulder can be tolerated. There are, however, many serious site-specific issues which must be addressed before the removal of a shoulder can be recommended.

3/ Maintenance operations and snow removal/storage are severely affected by the elimination of a shoulder. On core/collector type roadways not all shoulders fulfill the same functions. Generally, the left shoulder in the core roadway is the least important from maintenance and snow storage points of view.

4/ The removal of a shoulder and the subsequent provision of an additional lane adds to the capacity of the subject section. Upstream capacity and downstream bottlenecks provide a limit on the achievable capacity gain. In order to effect an improvement of existing conditions, the roadway must be considered as a total system and the impact of local changes on all parts of the system must be considered.

5/ Even when considered in isolation, the addition of a lane achieved through the removal of a shoulder does not result in a full lane's worth of capacity gain. The closeness of the guiderail, in particular when accompanied by narrower lanes, reduces the traffic carrying capability of all lanes. Based on theoretical calculations and experience elsewhere, the achievable capacity gain is in the order of 1200 vph.

6/ Freeway shoulders serve the important function of providing emergency parking space for disabled vehicles as well as access for the police to incidents. A significant portion of incidents which would result in a full lane blockage, without adequate shoulders, result in a far less severe shoulder blocking incident, as partially disabled vehicles can coast or be moved to the shoulder.

7/ For a constant demand volume the capacity provided by an additional lane will always result in a reduction of the delay caused by congestion and or incidents. Even following a lane-blocking incident, the residual capacity can be sufficient to minimize delays.

8/ The shoulders are generally not designed to carry through traffic on a continuous basis. The thickness of the asphalt and the slope of the shoulder are both inadequate for that purpose.

9/ The acceptance of geometric modifications by motorists reported by other jurisdictions is good. As long as the modifications are limited to relatively short and infrequent sections, motorists do not seem to experience difficulties in negotiating their vehicles through the section.

10/ The cost of modifying surface geometry to gain capacity will vary from site to site. In some cases only the removal of old lane markings and the placement of new ones is required. Other factors, such as reconstruction of the shoulder sign relocations, additional signing, drainage structures etc., may increase the cost significantly. However, the costs of modifying the geometry are low in comparison to the costs for new construction.

11/ "Modifying surface geometrics to increase capacity and to correct operational problems is an attractive solution because it is inexpensive, quickly implementable, effective and popular. However, it should not delay consideration of major reconstruction that freeways ultimately require."
("Modifying Freeway Geometrics to Increase Capacity," W.R. McCasland, TRB, Nov. 1980).

12/ Modifications of surface geometry to gain capacity is only one of several alternative strategies. Only the careful consideration of all site-specific issues will permit the selection of the best solution for the application intended.

7/ CASE STUDY

Based on the findings contained in the Highway 401 TMS Study Vol. 2, "Problem Identification," the section of the westbound express roadway extending from the basketweave to Highway 409 experiences heavy peak period congestion. It was this section which was selected for a case study intended to show the application of the considerations derived in Part I to a real situation.

7.1/ Geometric Characteristics of the Study Section (Basketweave to Hwy 409)

W/B Express Lanes

- General Direction: W/B
- Description: Express roadway (basketweave to Hwy. 409)
- Number of lanes: 3 (4 from Weston Road)
- Shoulder: left 2.1 m wide
  right 3.0 m wide
- Lane widths: 3.65 m
- Parallel roadway. collector
- Exit/Entrance: no exit or entrance ramps
- Length of section: 5 km
- Grade: +4%

7.2/ Operational Characteristics

Vehicles entering the expressway at the basketweave must complete their lane changes within a relatively short distance. The right lane of the transfer road terminates at the end of the acceleration lane and the left lane approximately at Jane Street. "Long" trucks are prohibited from using the left lane.

7.3/ Traffic Characteristics

• Average speed (peak):	45 km/h
• Accident characteristics:	183* accidents in 1981
• Peak volumes:	6 200 vph
• AADT.	62 000 vph
• Capacity (theoretical):	5 800 vph
• Truck %.	7.5%
• V/C ratio.	greater than 1
• (V/C) 1978 upstream section:	0.9
• (V/C) 1978 downstream section:	0.9
• Speed limit:	100 km/h

*Recorded accidents accident information system report -- #12, 82-02-30

7.4/ General

To examine the geometric feasibility of increasing capacity in the W/B express lanes from the basketweave to the transfer ramp to Highway 409, Central Region Planning was requested to investigate four design alternatives (see Exhibit A). The four alternatives were investigated and cost estimates prepared. According to the feasibility study, the alternatives are feasible from the geometric point of view (Exhibit B). The cost ranged from $760 000 for Scheme 1 to $2 400.00 for Scheme 4. Since this part of this report is only meant to illustrate the methodical use of the design and implementation considerations in a real application, only Scheme 1 will be investigated. For completeness sake all four Schemes are shown in Appendix A.

7.5/ Design and Implementation Considerations for the Use of Freeway Shoulders in the W/B Expressway from the Basketweave to Highway 409

7.5.1/ Lane Widths

As discussed in Section 2.1 of this report, it is assumed that freeway lane widths of 3.35 m are tolerable over short sections. Scheme 1, is based on 4 x 3.35 m lanes.

7.5.2/ Shoulders

In this section of the freeway, the right shoulder is 3 m (10 ft) and the left is 2.1 m (6.83 ft) wide. The narrower left shoulder serves as a refuge for emergency parking as well as a snow storage in the winter. The right shoulder, being much wider, is used more frequently for emergency and snow storage.

Space for stopping free of traffic lane

A typical shoulder configuration for the Hwy 401 express in this section is shown in Figure 2.

For maintenance as well as operational considerations the right shoulder is more important than the left shoulder.

Retaining the right shoulder permits trucks and many of the disabled vehicles to stop free of the traffic lanes. For the rare case of a motorist wanting to go for help, the left shoulder would require him to cross traffic lanes. Note also that the presence of CCTV surveillance will result in a quicker detection of disabled vehicles and thus reduce the need for motorists to leave their vehicles.

Safety Aspect of Shoulders

As described in the previous section, there is a greater need for the right shoulder than the left shoulder in the Hwy 401 express section considered in this study. If the left shoulder is used as an added traffic lane, more section capacity is created which, in turn, reduces the congestion caused accidents. Furthermore, it has been pointed out that several facilities both in Ontario and elsewhere operate successfully without a left shoulder. Table 6 in Part I of this study summarized the accident experiences for projects which contained geometric (shoulder lane) modifications to increase capacity. In almost all cases the accident experience has improved.

Shoulder and Lane Capacity

Up to a point, shoulders have a beneficial effect on capacity (see Table 4, Part I).

Table 8 shows the capacity gains which can be achieved by varying lane and shoulder widths. As can be seen from the table entries, the loss in capacity due to limited width or no shoulder is not very great. The capacity gained from adding a lane in this section of the freeway would be only slightly modified by the absence of a shoulder. If the lane width is also changed, the capacity is further affected and must be considered in the evaluation. The last entry in Table 8 reflects the geometric modifications studied. The entry shows that, if the left lane is eliminated, the right lane retained at 3 m and the present 3 x 3.65 m configuration is changed to a 4 x 3.35 m configuration, the increase in section capacity is 21.3%, instead of the expected 33%.

Structural Considerations

In general, the Highway 401 expressway shoulder design is 8.9 cm (3 1/2 in) of asphalt, over 30.5 cm (12 in) to 35.5 cm (14 in) Granular A and 0 to 15.3 cm (6 in) to Granular B. To facilitate drainage the cross-slope is 4%, and is higher than the slope of the driving lanes. It is not adequate to carry expressway traffic on a regular basis.

It must be pointed out that due to the truck prohibition in effect, it would not be required to carry heavy truck traffic. Extra work for curb and gutters, possibly adjustment of the guiderail height, plus catch basin modifications are required. The geometric feasibility design took all these factors into account to arrive at a cost figure.

7.5.3/ Incidents and the Shoulder

The accident/incident experience over this section which contains part of the basketweave is significantly worse than the average taken over the whole Bypass. The high accident/incident rates are the result of heavy congestion due to the presence of a transfer road which requires merging of high speed vehicles. The presence of continuous shoulders facilitates incident management in two ways:

- they provide access (police, ambulance etc.) to the accident site, and
- they provide parking space for disabled vehicles for accident investigation and tow truck arrival.

Access to Accident Site

Since the study section starts at the transfer road of the basketweave, it is accessible both from the W/B collector and the W/B expressway This factor makes it relatively easy for the OPP and ambulances to choose the appropriate roadway to approach an incident site. The Hwy. 401 TMS will further assist in the route choice. Within the section, the absence of a left shoulder will make the access to an incident site more difficult. But the increased capacity gained from the conversion of the shoulder to a travel lane should permit smoother traffic flow, even under lane-blocking incident conditions. Preliminary discussions with OPP officials suggest that from their view point there are great difficulties resulting from the elimination of the left shoulder over a limited section of the expressway (Appendix C).

Parking Space for Disabled Vehicles for Accident Investigation and Tow Truck Arrival

Lane-blocking accidents/incidents cause congestion and delays. The total delay in veh-h rises exponentially with increasing congestion (V/C). If following lane-blockage the residual capacity is not sufficient to satisfy the demand volume, queues are formed. The length of the queues increases until the capacity of the roadway satisfies or exceeds the demand volumes.

In the study section, the V/C ratio is so high that any lane-blocking incident gives rise to lengthy delays. Even after a vehicle has been moved (pushed) to the shoulder, a reduction in capacity remains in effect.

To assess the impact of "no-left-shoulder" requires that one examine:

- the increase in lane-blocking conditions in the absence of a left shoulder, and

- the results of incidents in veh/h.

Increase in Lane-Blocking Conditions

To estimate the increase in lane-blocking conditions in the absence of a left shoulder the QEW traffic incidents in 1979 E/B (a.m. rush) were

compared to those provided by TTI* (Guidelines for Selection of Ramp Control System No. 3-22A, 1981). The TTI provide an average figure obtained from many facilities (Table 10). The results of the QEW experience are shown in Table 9. Whereas the QEW shows 63.5% of all types of incidents to be lane-blocking incidents, the TTI quotes an average of 50%. Lacking better data, the increase in lane-blocking incidents will be attributed to the absence of a left shoulder (QEW), (i.e., without a left shoulder there are 13.5% more incidents which result in lane-blocking than with a right and left shoulder).

Impact of Incidents

The higher capacity provided through an additional lane has a beneficial effect on the incident caused delays. Since the sections upstream of the study section are capacity restricted, the capacity gained in the study section remains "protected" in the future. The impact of incidents on capacity is shown in Table 10.

For the study section, a lane-blocking incident under the present conditions results in a residual capacity of 53.2% (100-46.8). With an extra lane added, the capacity is increased to 123% compared to the existing capacity and a single lane-blocking incident would reduce this by 44% (Table 10). The resultant capacity is 70% of the existing capacity. The increase in residual capacity can be directly translated to delay time saved. In addition, once the disabled vehicles have been pushed to the side of the roadway, the queue that has been formed "clears" at the capacity flow rate which, of course, is much higher for the four-lane roadway than for the three-lane roadway. Figure 3 shows the general delay conditions which follow on incident. Using a computer program (DEL), the delays for lane-blocking incidents were evaluated for both the existing and the four lane conditions.

7.5.4/ Benefit Calculation

The results and assumptions for the delay calculations are shown in Tables 11 and 12. It is quite evident, however, that the four-lane

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*Texas Transportation Institute

roadway offers significant relief over the existing condition. Per lane-blocking incident there is a 1395 - 195 = 1200 veh-hr saving associated with the four-lane configuration.

According to the LRecorded Accident Information System Report (#12, 82-02-30), there were 183 accidents in the section of the W/B expressway extending from the basketweave to Hwy 409. If one assumes that there are two to three times as many incidents as these accidents, the total number of accidents plus incidents is 732/year for the section under study.

Based on the results derived in 7.5.3 with shoulders on both sides, 50% of all these incident will be lane-blocking and without a left shoulder 63.5%. Consequently, the yearly incident-based gain in veh-h due to the four-lane configuration is:

$$\text{Gain in Incident Delay } \frac{\text{veh-h}}{\text{year}} =$$

$$\frac{1}{2} \times \left(\frac{\text{Number of Incidents}}{\text{year}} \times \text{Fraction Lane Blocking} \times \text{Delay/Incident}\right) - \text{4 lane capacity}$$

$$\left(\frac{\text{Number of Incidents}}{\text{year}} \times \text{Fraction Lane Blocking} \times \text{Delay/Incidents}\right) \text{existing} =$$

$$\frac{1}{2}\,(732 \times 0.5 \times 1395)_{\text{existing}} - (732 \times 0.635 \times 195)_{\text{4 lane config}} = 210\,000\ \frac{\text{veh-h}}{\text{year}}$$

The value of $\frac{1}{2}$ is used to account for peak period incidents only.

Travel Time Saving

Based on information derived from Vol. 2 of the Highway 401 TMS report, average speed over the subject section was 45 km/h. With a fourth lane added, the average speed over this 3 km section will rise to 65 km/h*. The travel time saved with a peak volume of 6 200 veh/h, two peak periods of 2 h each, 250 days can be calculated as:

$$6\,200\ \frac{\text{veh}}{\text{hr}} \times \frac{4\ \text{h}}{\text{day}} \times 250\ \frac{\text{days}}{\text{year}} \left(\frac{1}{45} - \frac{1}{65}\right) \frac{\text{h}}{\text{km}} \times 3\ \text{km} = 127\,200\ \text{veh-h/year}$$

---

*estimated from repeated applications of Davidson's formula for travel time.

This figure does not take into account any time loss associated with maintenance actions in the peak period.

Accident/Incident Reduction Benefits

This is a very controversial issue. Whereas data derived from experience (see Part 1) shows either a reduction or no change in the accident, many (see Appendices B & C) feel that eliminating the left shoulder in the section will lead to an increase in the number of accidents. Neither the QEW data (no left shoulder) nor data from other operating agencies support this view. There will be neither a benefit nor a disbenefit assumed for this.

Total Benefit

The total benefit consits of three main elements: Travel Time Saving, Fuel Cost Saving and Incident Delay Saving.

$$\text{Total Benefit (\$/year)} = 127\ 200\ \frac{\text{veh-h}}{\text{year}} \times \left(1.2\ \frac{\text{persons}}{\text{veh}} \times 4\$/\text{person-h} + 3.2\ \frac{1}{\text{veh-h}} \times .41\$/\text{litre}\right)$$

$$+\ 210\ 000\ \frac{\text{veh/h}}{\text{year}} \times \left(1.2\ \frac{\text{persons}}{\text{veh}} \times 4\$/\text{pers/h} + 3.2\ \frac{1}{\text{veh-h}} \times .41\$/1\right)$$

$$= 776\ 000 + 128\ 000 = \$2.06\ \text{M/year}$$

It can be seen that the greatest benefit arises from the delay costs saved under incident conditions and not from the decreased travel time costs. For comparison purposes, the Highway 401 TMS system is projected to bring a benefit of 3 to 5 $M/year.

7.5.5/ Disbenefits

Some of the disbenefits are not readily quantifiable. In such instances one must rely on similar experiences elsewhere.

Disbenefit $/year = Annual Maintenance Cost + Travel Time Delays due to Maintenance + Annualized Construction Cost

$$= 20\ 000\ \$/\text{year} + 20\ 000\ \frac{\text{veh-h}}{\text{year}}\ \ 1.2\ \frac{\text{pers}}{\text{veh}} \times \frac{4\$}{\text{per-h}} + 3.2\ \frac{1}{\text{veh-h}} \times 0.41\ \$/1\ \ + 750\ 000 \times 0.14\ \$/\text{year} = 250\ 000\ \$/\text{year}$$

Benefit to Cost Ratio

$$B/C = \frac{2.06\ \$M/year}{.25\ \$M/year} = 8.2$$

Scheme 1, which eliminates the left shoulder and uses the shoulder for an added fourth lane, results in a very favourable benefit to cost ratio.

Increased Maintenance/Snow Removal

Appendix B prepared by District 6 Maintenance staff provides a comprehensive evaluation associated with the increased maintenance activities for the 3 km section from the basketweave to Highway 409 W/B express. The total additional Annual Maintenance cost is quoted at $20 000.

This figure must be increased to include the delays associated with the maintenance actions without a left shoulder.

If we assume that all 512 h of summer maintenance will take place in the peak period, a substantial disbenefit is incurred. The actual delays are not easily calculated but can reach 20 000 veh-h/yr.

Operational Disbenefits

There are several operational disbenefits. For one at Highway 409, the existing "either-or" lane condition will disappear and a "two right lanes must exit" condition will be created.

8/ ALTERNATIVES

As pointed out earlier, the conversion of a freeway shoulder to a driving lane over a limited freeway section is only one of several alternatives. All of the alternatives must be traded off against each other to arrive at the best solution. In the freeway section under consideration, alternatives have been identified:

- permanent signing changes -- to encourage better express/collector balance
- changeable message signing -- as above
- additional transfer road between Leslie St. and the Basketweave
- major geometric changes
- combination of above four

No attempt will be made to evaluate the benefits and disbenefits of the above listed alternatives. They are only meant to show the type of alternatives the freeway-shoulder-use option has to compete with.

Table 1/ Comparison of QEW and Hwy. 401 Accident Rates

	LHRSNO	1980 ACCID	km	AADT	CALC AR.	AR incl RAMPS
QEW	10 140	45	1.8	79 600	.86	.90
	142	41	2.1	79 700	.67	.7
	144	62	4.1	101 000	.41	.4
	146	107	2.1	109 600	1.10	1.4
	150	92	1.9	120 000	1.11	1.3
	151	59	2.1	112 850	.68	.7
		406	14.1 x	100 702 = AVG.	0.78 accidents/10^6 veh-km	
				AVG AADT		

COLLECTOR LANES ONLY

401	47 624	62	1.5	108 650	1.04	1.3
		7	0.9	108 650	0.20	.6
	625	13	1.8			
		6	0.9	34 260	0.53	
	626	26	1.6	44 950	0.99	.8
	627	44	2.6	84 490	0.55	.5
	629	54	1.6	82 220	1.12	.8
		199	9.1 x	7554 = AVG.	0.76 accidents/10^6 veh-km	
				(AVG. AADT)		

Table 2

Hwy. 401 FIXED OBJECT COLLISIONS
LEFT SIDE ONLY

Hwy. 401 Morningside Ave. to Warden Ave. (Collector roads only)

Total 60 accidents involving fixed objects on the left shoulder in 1980

Length of selected section = 9.1 km

Travel Experience

	Length	1980 AADT	Travel Experience
Morningside - Neilson	1.5	108 650	59.48
Neilson - Hwy. 48	1.8 (0.9	108 650	35.69
	(0.9	34 230*	11.2
Hwy. 40 - McCowan	1.6	44 950*	26.2
McCowan - Kennedy	2.6	84 490*	80.1
Kennedy - Warden	1.6	82 220*	48-0
	9.1 km		260.7
			millions of veh-km

*Collector Roads only

Partial

$AR = \frac{60}{260.7} = 0.23$ accidents/10^6 veh-km

or accidents per km $\frac{60}{9.1} = 6.6$

% of total accidents involving fixed object left side $\frac{60}{199} = 30.1\%$

Table 3

QEW FIXED OBJECT COLLISIONS
LEFT SIDE ONLY

QEW Ford Drive to Dixie Road

Total of 168 accidents involving fixed objects on the left shoulder in 1980.
Length of selected section = 14.1 km

TRAVEL EXPERIENCE	Length	1980 AADT	TE
Ford Drive - Winston Churchill Blvd.	1.8	79 600	52.30
Winston Churchill Blvd. - Erin Mills P.	2.1	79 700	61.09
Erin Mills R. - Mississauga Rd.	4.1	101 000	151.15
Mississauga Rd. - Hwy. Rd.	2.1	109 600	84.00
Hwy. 10 - Cawthra Road	1.9	120 000	83.22
Cawthra Road - Dixie Road	2.1	112 850	86.50
	14.1 km		578.26
			Millions of vehicle-km

Partial

$$\underset{(1980)}{AR} = \frac{168}{578} = 0.32 \text{ accidents } /10^6 \text{ veh-km}$$

or accidents per km $\frac{168}{14.1} = 11.8$

% of total accidents involving fixed object left side $\frac{168}{406} = 41.4\%$

Table 4/ Combined Effect of Lane Width and Restricted Lateral Clearance on Capacity (Source HCM, April 1972)

Distance from traffic lane edge to obstruction	ADJUSTMENT FACTOR					
	Obstruction on one side of one-direction roadway			Obstruction on both sides of one-direction roadway		
(m)	3.65 m lanes	3.35 m lanes	3.05 m lanes	3.65 m lanes	3.35 m lanes	3.05 m lanes
1.825	1.00	0.96	0.89	1.00	0.96	0.89
1.22	0.99	0.95	0.88	0.98	0.94	0.87
0.61	0.97	0.93	0.87	0.96	0.92	0.85
0	0.94	0.91	0.85	0.91	0.87	0.81

Table 5/ Theoretical Capacity Gain Achievable by Varying Lane and Shoulder Widths as well as the Number of Lanes

CONFIGURATION DESCRIPTION	APPLICABLE CAPACITY FACTOR	TOTAL CAPACITY	PERCENTAGE CHANGE FROM EXISTING CAPACITY
3 lanes [3 m shoulder, 3 x 3.65 m lanes] (existing design)	1.0	3.0	0%
3 lanes [1.825 m shoulder, 3 x 3.65 m lanes]	1.0	3.0	0%
3 lanes [1.2 m shoulder, 3 x 3.65 m lanes, obst. 1 side]	0.99	2.97	-1%
3 lanes [2 x 1.2 m shoulder, 3 x 3.65 m lanes]	0.98	2.94	-8%
4 lanes [1 x 1.2, 1 x 3 m shoulder; 2 x 3.65 + 2 x 3.35 m]	0.97	3.88	+29.3%
4 lanes [1 x 0.6, 1 x 3 m shoulder, 2 x 3.65 + 2 x 3.4 m]	0.95	3.8	+26.7%
4 lanes [1 x 0, 1 x 3 m shoulder, 2 x 3.65 + 2 x 3.35 m]	0.94	3.76	+25.3%
4 lanes [2 x 0 m shoulder, 4 x 3.65 m]	0.94	3.76	+25.3%
4 lanes [1 x 0 m + 1 x 3 m, 4 x 3.35 lanes]	0.91	3.64	+21.3%

Table 6/ Summary of Operational Experience (3)

City (1)	Freeway (2)	Capacity increases from-to in vehicles per hour (3)	Delay reduction in vehicle-hours per day (4)	Speed increases from-to in miles per hour (5)
Denver	1-25	6376 to 7146	500	26 to 46
Houston	Southwest (U.S. 59)	5800 to 7100	1000	——
Los Angeles	Santa Monica (I-10)	7680 to 9600	850	22 to 40
	San Bernardino	6900 to 7600	850	
	Pomona	(Provided truck climbing lane)	100	30 to 40
	Ventura	7700 to 8500	750	30 to 56
	Golden State	Increased volumes	820	37 to 55
	Santa Ana	7700 to 8500	625	20 to 50
Nashville	I-65, I-265	4150 to 5200	——	Free flow
Portland	I-5, I-405	3400 to 4120	——	Free flow
	Banfield	Vehicles— +2% Persons— +10%	——	33 to 38
San Francisco	Route 280	5460 to 7090	250	——

Note: 1 mph = 1.61 kph

Table 7/ Summary of Accident Experience (3)

City (1)	Freeway (2)	Safety evaluation/changes in accident rates (3)
Denver	1.25	No increase in accident experience
Houston	Southwest (U.S. 59)	Rates reduced from 2.68 to 2.90 accidents/1 000 000 vehicle-miles overall: 7.73 to 3.78 accidents/1 000 000 vehicle-miles in peak periods.
Los Angeles		
	Santa Monica (I-10)	Rates reduced from 1.45 to 1.05 accidents/1 000 000 vehicle-miles.
	San Bernardino	Project greatly improved the overall safety.
	Pomona	Rates reduced from 1.32 to 1.05 accidents/1 000 000 vehicle-miles
	Ventura	Rates reduced from 1.86 to 0.78 accidents/1 000 000 vehicle-miles
	Golden State	Rates reduced from 1.93 to 1.47 accidents/1 000 000 vehicle-miles.
	Santa Ana	Accident frequence increased 50% for 8 months. Changes made in signing, pavement markings, hours of usage reduced accident rate from 2.39 to 2.17 accidents/1 000 --- vehicle-miles.
Nashville	I.65, I-265	Rate reduced from 1.92 to 0.91 accidents/1 000 000 vehicle-miles.
Pensacola	I.10	Only one accident reported in 1 yr.
Portland	I.5, I.405	Rate reduced from 4.69 to 1.30 accidents/1 000 000 vehicle-miles.
	Banfield	Accident rate increased slightly.
San Francisco	Route 280	No problems reported.
Seattle	Route 520	No increase in accident experience.

Note: 1 accident/1 000 000 vehicle-miles = 0.62 accidents/1 000 000 vehicle-kilometres
Source: W.R. McCasland, TRB Nov. 1980.

Table 8/ Theoretical Capacity Gain Achievable by Varying Lane and Shoulder Widths as well as the Number of Lanes

CONFIGURATION DESCRIPTION	APPLICABLE CAPACITY FACTOR	TOTAL CAPACITY	PERCENTAGE CHANGE FROM EXISTING CAPACITY
3 lanes [3 m shoulder, 3 x 3.65 m lanes]	1.0	3.0	0%
3 lanes [1.825 m shoulder, 3 x 3.65 m lanes]	1.0	3.0	0%
3 lanes [1.2 m shoulder, 3 x 3.65 m lanes, obst. 1 side]	0.99	2.97	-1%
3 lanes [2 x 1.2 m shoulder, 3 x 3.65 m lanes]	0.98	2.94	-8%
4 lanes [1 x 1.2, 1 x 3 m shoulder; 2 x 3.65 + 2 x 3.65 m]	0.97	3.88	+29.3%
4 lanes [1 x 0.6, 1 x 3 m shoulder, 2 x 3.65 + 2 x 3.35 m]	0.95	3.8	+26.7%
4 lanes [1 x 0, 1 x 3 m shoulder, 2 x 3.65 + 2 x 3.35 m]	0.94	3.76	+25.3%
4 lanes [2 x 0 m shoulder, 4 x 3.65 m]	0.94	3.76	+25.3%
4 lanes [1 x 0 m + 1 x 3 m, 4 x 3.65 lanes]	0.91	3.64	+21.3%

Table 9/ QEW Traffic Incidents (1979) E. Bound (a.m. Rush)

INCIDENTS			LOCATION				
Accidents	vs	Non-Accidents	D/Lanes (Lane Blocking)	Rt. Shoulder	Shoulder Blocking	Lt. Shoulder	Median
		63	63				
		36		36			
		0				0	
		2					2
43			43				
19				19			
0						0	
4							4
66		101					

Table 10/ Capacity Reductions Due to Incidents

Incident type	Fraction of All Types of Incidents	% Capacity Reduction by No. of Freeway Lanes 2	3	4	5
Vehicle/Persons on Shoulder	0.48 (+0 38)	25.0% (+8.67%)	16.0% (+5.48%)	10.7% (+4.04%)	*
One-Lane Blockage	0.45 (+0.37)	67.5% *	46.8% (+4.60%)	44.0% (+8.62%)	25.0% *
Two-Lane Blockage	0.053 (+.044)	100% *	78.3% (+5.77%)	66.3% (+6.29%)	50% *

*Insufficient data: two or less data points

Table 11/ Assumptions and Results for Delay Calaculations Under (Existing Conditions)

The capacity flow rate is = 96.7 veh/min = S1
The demand flow rate is = 96 veh/min = S2
The initial bottleneck flow rate is = 54.1 veh/min = S3
The adjusted flow rate is = 82.2 veh/min = S4
The revised demand flow rate is = 90 veh/min = S5
The incident duration is = 20 min = T1
The total facility closure time is = 0 min = T2
The duration of adjusted flow conditions is = 20 min = T3
The elapsed time under initial demand conditions is = 3.5 min
qmax = 739 vehicles
tnf = 173.5822 minutes
delay = 83681.26 veh-min or 1394.688 veh-h.

Table 12/Assumptions and Results for Delay Calculations under 4 Lane Conditions

The capacity flow rate is = 120 veh/min
The demand flow rate is = 96 veh/min
The initial bottleneck flow rate is = 69 veh/min
The adjusted flow rate is = 102 veh/min
The revised demand flow rate is = 90 veh/min
The incident duration is = 20 minutes
The total facility closure time is = 0 minutes
The duration of adjusted flow condition is = 20 minutes
The elapsed time under initial demand conditions is = 3.5 minutes
qmax = 441 vehicles
tnf - 46.7 minutes
delay = 11676.6 veh-min or 194.61 veh-h
(see Figure 1)

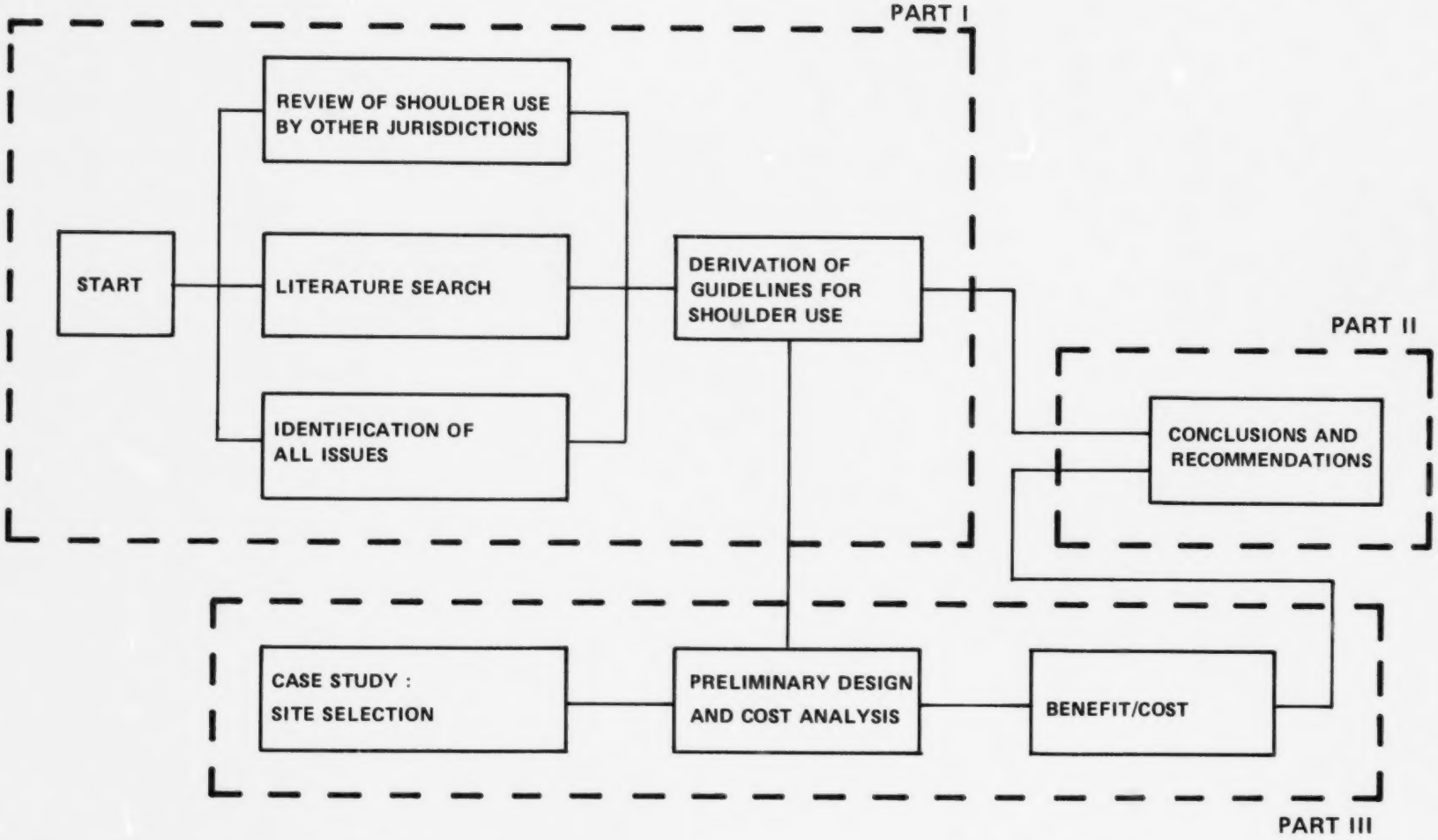
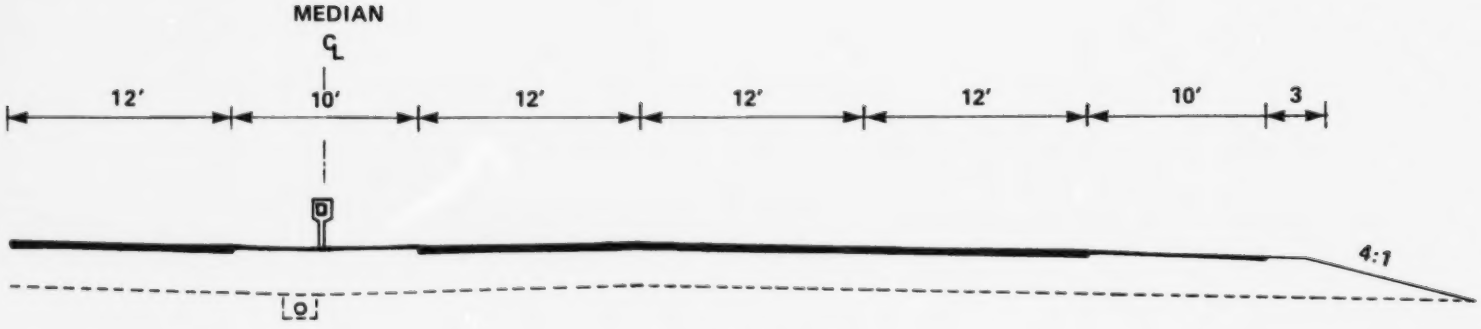
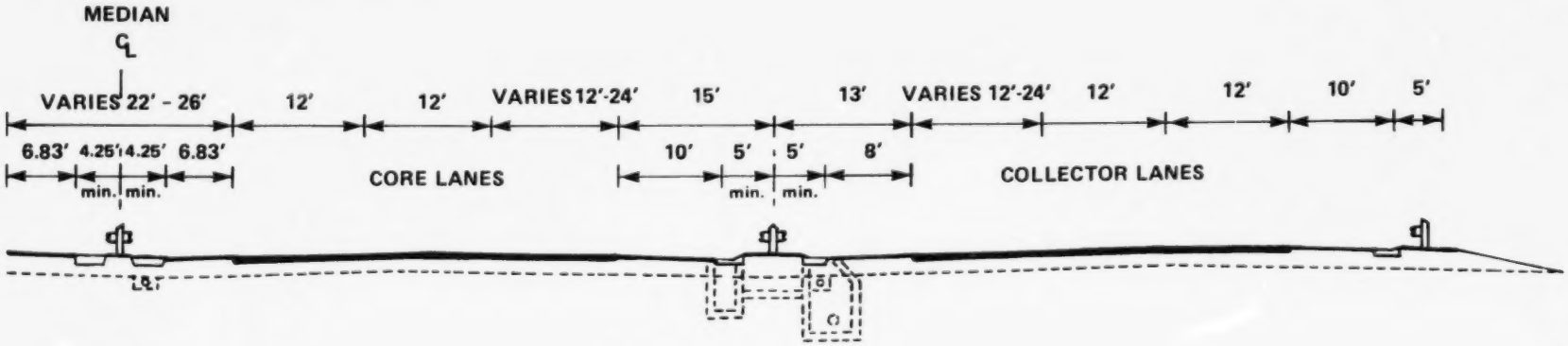


Figure 1/ Study Outline



SIX LANE SECTION



C - D SECTION

Figure 2/ Highway 401 Typical Cross-Section

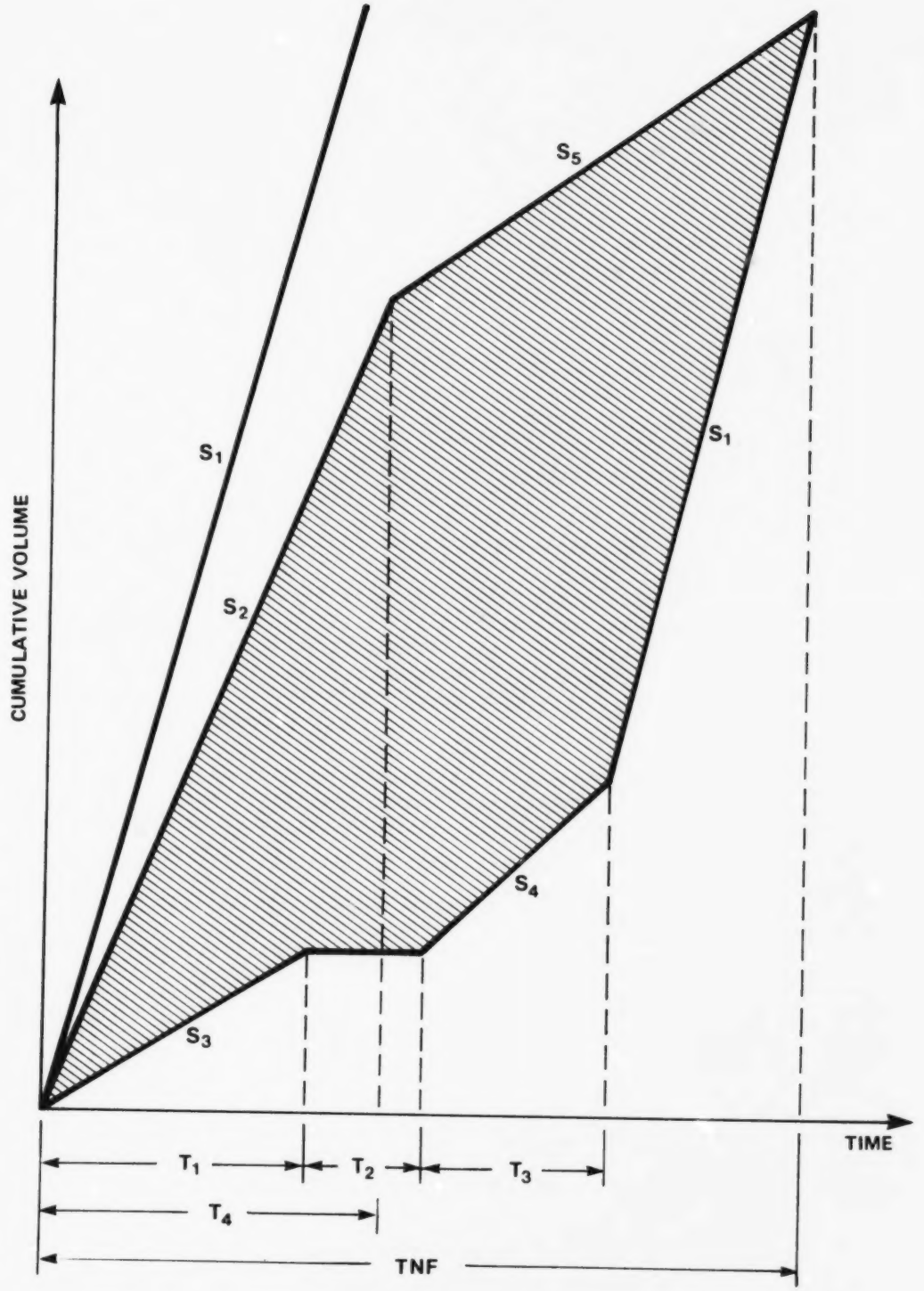


Figure 3/ General Delay Condition

APPENDIX A

memorandum

Ontario

Planning & Design Section, Central Region 224-7658

To: G. Abrahamsohn
Control Systems
Research and Development Branch
3rd Floor Central Building
1201 Wilson Ave., Downsview

Date: June 3, 1982

Re: Freeway Shoulder Use
Cost Estimates of alternative designs.
W. Bound Express lanes from Basketweave (west of Keele St.) to transfer ramp to Hwy. 409

Further to your request and letter of 82-05-14 I am enclosing preliminary cost estimates of four alternatives investigated by our office. Also you will find schematic cross-sections illustrating the four alternatives and copies of a plan view of the initiation of a 4th through lane at the Basketweave (just west of Keele St.) and the terminal area of the 4th lane at the transfer ramp to Hwy. 409.

The alternatives are feasible from the geometric point of view.

From the traffic operation point of view, the required treatment to introduce the 4th lane will result in the elimination of the existing "squeeze lane" merging at the Basketweave (an advantage); in the west terminal of the 4th lane, the existing "either-or" lane condition will disappear and a "Two-right lanes must exit" condition will be introduced, (a disadvantage).

Our office is still very concerned with the principle of bastardizing a two mile section of express lanes by eliminating the left shoulder, which we consider to be one of the corner-stones of an appropriate freeway cross-section.

The Hwy. 401 Traffic Management Program, being developed for implementation, may offer possible solutions to alleviate congestion through this two-mile section of the W. Bound express lanes; either by use of appropriate messages encouraging motorist to use the collector lanes and/or perhaps providing additional opportunities to transfer from express to collector lanes. This may balance traffic flows between core and collector and alleviate the problem without losing one of the main features of the Hwy. 401 continuous existing cross-section.

Some of the "trade-offs" involved for the assessment of a recommendation in this matter will be difficult to quantify and since there will be a substantial number of such factors to consider, perhaps a Kepner-Tregoe approach to the final evaluation of alternative courses of action should be contemplated.

Should you need further information and/or clarification of the attached material, please give me a call.

I. Ardizone
Area Engineer
Planning, Central Region

IA:jm
cc: R. Shannon
F. Norman
W.C. Friedmann
J. Klowak

APPENDIX B

memorandum

Ontario

To: Mr. G. Abrahamsohn
Senior Research Engineer
Control Systems
Research & Development Branch
Central Building, Downsview

Date: 1982-07-22

Re: Freeway Shoulder Usage
Maintenance Operations

Further to our recent discussions I list below the various maintenance activities associated with the core median which would be affected by elimination of the left shoulder and conversion to a driving lane.

1. Regular Summer Maintenance

   a) Catch basin clean out
   b) Winter sand removal
   c) Debris removal
   d) Guide rail repairs
   e) Illumination relamping
   f) Sign structure maintenance

2. Winter Maintenance

   a) Snow plowing
   b) Sanding and salting
   c) Snow removal

1. As the proposal under investigation is for a limited 3 km section of westbound core, from the Jane Street basket-weave to Highway 409, it becomes extremely difficult to analyse in detail the monetary impacts on our maintenance operations as the total median workload on a single patrol is not affected but rather a spot situation. Rather than directly increasing the costs of Summer Operations outlined above the only major quantifiable increase would involve additional lane closing and traffic control procedures. At present these operations can generally be carried out within the limits of the shoulder itself, expecially debris removal. In addition certain operations on the eastbound shoulder would require a closure of the proposed westbound lane whereas at present the westbound shoulder provides the appropriate safety offset to our operations.

Summer Operation	Addition Annual Requirements				
	Labour		Equipment		Total
	Hrs.	$	Hrs.	$	$
(a)	32	325	32	800	1125
(b)	48	500	48	1200	1700
(c)	200	2000	100	2500	4500
(d)	200	2000	100	2500	4500
(e)	16	160	8	200	360
(f)	16	160	8	200	360
		$5145		$7400	$12,545

2. The additional costs associated with winter operations are more directly related to the actual work. i.e.,

- Snow plowing - additional lane to plow on initial pass
- Sanding and Salting - additional lane to spread
- Snow removal - increased potential for removal at the core/collector median

It is assumed that for this limited spot section no additional staff or equipment inventory is required. This position would not hold true for expansion of the proposal.

Additional Costs

2. a) - 120 passes per lane per year at $1.64 per km for 3km = $600 per year

2. b) - Cost per lane km per year = $700
For 3km = $2100

2. c) - Assume one additional pick-up per 3 km length (3 days) = $4000

Total additional winter costs - $6,700

Total additional Annual Maintenance costs - $19,345

While the above outlines a very rough assessment of the potential additional maintenance costs associated with the loss of the left

Mr. G. Abrahamsohn 1982-07-22

median shoulder to a driving lane the presentation of this data must not be construed in any way as District 6's acceptance of the proposal. Rather the above outlined potential financial implications tend to cement our previously stated position that the loss of the shoulder would be a regressive step involving an increased hazard to both the motoring public, our maintenance activities, and especially Ministry workmen (please note the implications of Bill 70), while providing only a marginal capacity improvement.

In addition to the many well documented benefits for the operation of a safe, efficient highway, the presence of a shoulder provides the only lifeline available to the Maintenance forces to carry out the many activities which in turn keep the highway in a safe and efficient state. The importance of these maintenance activities is tending to grow with the age of the facility. The type and extent of our present operations differs from those envisaged at the opening of Highway 401 and I am sure the future requirement will also hold changes.

The removal of the present shoulder eliminates the flexible use resource which we consider of utmost importance to our present maintenance operations, and which may have even greater significance in the future.

Should you wish to discuss the above or any additional points on this major policy issue, please do not hesitate to contact me further.

D. ASPINWALL
District Maintenance Engineer

DA:at

cc: J. Childs
W. Friedmann
I. Ardizone
R. A. Shannon
T. J. Walsh

APPENDIX C

Ontario Provincial Police

Ministry of the Solicitor General

Telephone 248-3151

No. 5 District Headquarters
Box 327, Downsview, Ontario
M3M 3A6

12 July 1982

District Engineer
No. 6 District MTC
5000 Yonge Street
Willowdale, Ontario
M2N 6E9

Dear Sir

Re: Hwy. 401 Shoulders

In reply to a meeting at MTC where the use of the shoulders on Hwy. 401 for vehicular traffic was discussed, I wish to submit the opinions of the O.P.P. No. 5 District.

Although the use of the left shoulder may increase the volume capacity of the freeway, the problems that it would create far outways the advantages. All our cars are equipped with push bumpers so the damaged cars can be pushed onto the shoulder allowing the stopped traffic to continue. Tow trucks can then use the shoulder for hookups while the officer obtains the required information. The majority of speeding violators are travelling in the left lane and can be pulled onto the left shoulder. If there were no shoulder, it would be too dangerous to cause the violator and police car to move across three to four lanes to stop.

Broken down vehicles pull onto the shoulder and are assisted by your emergency vehicles, tow trucks and our cars with no disruption to traffic. When traffic slows or stops in the lanes, the following vehicles who can't stop can pull to the shoulders eliminating an accident. With no shoulder, there is no escape route which is the reason there is a greater number of rear end collisions on the Q.E.W., with no rail shoulder.

The use of the left shoulder on Hwy. 401 westbound from Hwy. 400 to Hwy. 409 in the collector lanes during construction this summer, has resulted in a large increase of accidents and produced considerable problems for our officers in trying to investigate the accidents and tow vehicles away, a clear indication of the problems that would develop. Maintenance of the guide rail would increase with more collisions requiring more lane closures for repairs. Elimination of the shoulder would create a more dangerous situation for all personnel who have to work on the highway, cause more accidents adding to the workload when we are now at minimum strength. Although last winter was an exception without a rail shoulder, there is no place to plow the snow to.

As indicated, the O.P.P. do not support the idea of using any shoulders on Hwy. 401 for vehicular traffic.

Yours truly

A.M. WILKINSON
A/INSPECTOR FOR
THE SUPERINTENDENT

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